(54) Title: QUALIFYING TELEPHONE LINES FOR DATA TRANSMISSION
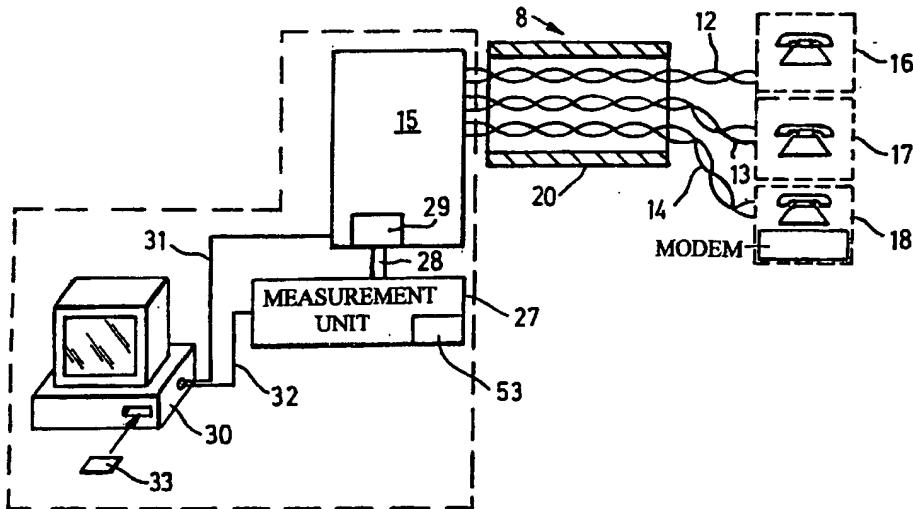
(57) Abstract: The method assesses the suitability of customer telephone lines (12, 13, 14) for data transmission. The method includes selecting a telephone line having tip and ring wires by means of a computer (30) and switch (15), and electrically connecting the tip and ring wires together at a test access (29) adjacent one end of the selected line to produce a common mode configuration. Single-ended electrical measurements are performed on the wires in the common mode configuration by a measurement unit (27) connected to the test access (29) to determine an electrical property of the wires from the measurements.

QUALIFYING TELEPHONE LINES FOR DATA TRANSMISSION

Background of the Invention

5   This invention relates generally to telephone lines,
and more particularly, to qualifying telephone lines for
data communications.

         Public switched telephone networks, e.g., plain old
telephone systems (POTS), were originally designed for voice
10   communications having a limited frequency range. Today, the
same POTS networks often carry data transmissions using
higher frequencies. The difference in frequencies suggests
that some POTS lines, which function well for voice, will
function poorly for data. The risk of poor quality data
15   transmissions has motivated telephone operating companies
(TELCO's) to develop tests for predicting the quality of
lines for data transmissions.

         One quality test uses physical line length to
determine a line's attenuation. The attenuation of a line
20   whose length is less than about four kilometers (km) is
usually low enough for data transmission. But, measuring
the line length is typically more involved than measuring
the straight line distance between a customer's address and
a switching station. Typically, lines form branching
25   structures rather than going radially from the switching
station to the customer addresses. Thus, determining a line
length usually entails manually mapping the actual branching
structures connecting the customer to the switching station.
Such complex manual techniques can be time intensive and may
30   lead to errors.

         Furthermore, determining that a line's length is
less than a preselected limit, e.g., four km, may be
insufficient to qualify the line for data transmission. The
line's attenuation also depends on the physical properties
35   of each branch segment making up the line, e.g., the gauge
mixture of the line. In lines having segments with

different properties, the above-described mapping technique
generally should take into account the properties of each
segment to determine the total attenuation of the line.

5   TELCO's have also used direct electrical tests to
determine the quality of POTS lines for data transmissions.
Typically, such tests are manual and two-ended. Two-ended
tests involve sending one employee to a customer's address
or final distribution point and another employee to a
switching station. The two employees coordinate their
10   activities to perform direct electrical measurements on the
customer line using hand-held devices. These two-ended
measurements are substantially independent of the
termination characteristics at the customer's address.

        Nevertheless, these two-ended tests need two
15   separate employees, which makes them labor intensive. The
labor requirements affect the cost of such tests. The two-
ended tests cost about $150 per customer line. This cost is
so high that a TELCO is often prohibited from using such
tests for all customer lines.

20   The present invention is directed to overcoming, or
at least reducing, one or more of the problems set forth
above.

<u>Summary of the Invention</u>

        In a first aspect, the invention provides a method
25   of assessing the suitability of customer telephone lines for
data transmission. The method includes selecting a
telephone line via a test access of a switching station and
electrically connecting the tip and ring wires adjacent one
end of the selected line in a common mode configuration.
30   The method also includes performing single-ended electrical
measurements on the tip and ring wires with respect to
ground by driving the tip and ring wires in the common mode.

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The method includes determining an electrical property of
the wires from the single-ended measurements.

In a second aspect, the invention provides a system
for determining a signal attenuation of a customer line.
5   Each customer line has tip and ring wires. The system
includes a measurement unit having first and second input
terminals to couple to a test access of a telephony switch.
The measurement unit is capable of driving the input
terminals in a common mode configuration with respect to
10   ground to perform single-ended impedance measurements on the
tip and ring wires of the customer lines in the common mode
configuration.

In a third aspect, the invention provides a method
of marketing customer telephone lines for selected data
15   transmission services. Each line has associated tip and
ring wires. The method includes automatically performing
single-ended electrical measurements on the customer
telephone lines and determining which of the customer lines
qualify for a selected data transmission service from the
20   measurements. The tip and ring wires are driven in a common
mode configuration during at least a portion of the
measurements upon the associated lines. The method includes
sorting the lines by distribution point and qualification to
transmit data. The method also includes offering the
25   selected data service to a portion of the customers in
response to lines determined to be qualified for the service
being available.

Brief Description of the Drawings

Other objects, features, and advantages of the
30   invention will be apparent from the following description,
taken together with the drawings in which:

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FIG. 1 shows an embodiment of a system for testing the suitability of customer lines for data transmission;

FIG. 2 shows the segments of one customer line from FIG. 1;

5   FIG. 3 is a flow chart illustrating a method of testing telephone lines for data transmission;

FIG. 4 shows a portion of the measurement unit that performs impedance measurements on the lines of FIG. 1;

FIG. 5 is a flow chart for a method of qualifying

10   customer lines using low frequency measurements on tip and ring wires driven in a common mode configuration with respect to ground;

FIG. 6 is a table comparing attenuations found with the methods of FIG. 5 to reference values; and

15   FIG. 7 is a flow chart illustrating a method of marketing data transmission services for customer lines.

Description of the Preferred Embodiments

FIG. 1 shows a portion of a POTS network 8. The network 8 includes customer lines 12-14 connecting customer

20   units 16-18, i.e., telephones and/or modems, to a telephony switch 15 located in a TELCO central office 10. The switch 15 may be a POTS switch or any other device for connecting the lines 12-14 to the telephone network 8, e.g., a digital subscriber loop access multiplexer (DSLAM) (not shown).

25   Each customer line 12-14 is a twisted copper two-wire pair adapted for telephone voice communications. The two wires of each line 12-14 are generally referred to as the ring and tip wires. The lines 12-14 are contained in one or in a series of standard telephony cables 20. The

30   cable 20 may carry more than a dozen customer lines (not all shown) thereby creating an environment that changes electrical and transmission properties of the separate lines

12-14. The properties of the lines 12-14 may also depend on their segment structure.

FIG. 2 shows that the customer line 12 has several paired copper two-wire segments 21-23. The segments 21-23
5 are located in separate cables 20, 24-25 and couple serially through couplers 26. Each segment 21-23 may have a different length and/or gauge than the other segments 21-23. The segmented structure of the line 12 can affect electrical properties, e.g., the signal attenuation.
10   Referring again to FIG. 1, single-ended measurements on the lines 12-14 are performed with a measurement unit 27 located in the central office 10. The measurement unit 27 couples, via a line 28, to a standard voice test access 29 of the switch 15. The test access 29 provides electrical
15 couplings to selected customer lines 12-14 in a voice frequency range of at least between 300 Hertz (Hz) and 4 kilo-Hz (KHz), i.e., a low frequency range. The measurement unit 27 uses the test access 29 to perform a single-ended measurements on the lines 12-14, e.g., impedance
20 measurements.

The line testing is controlled by a computer 30. The computer 30 sends signals the switch 15, via line 31, e.g., to select the line 12-14 to be tested. The computer 30 sends signals to the measurement unit 27, via line 32, to
25 select and control the test to be performed. The measurement unit 27 sends measurement results to the computer 30 via the same line 32.

The computer 30 includes a storage medium 33 encoding an executable software program for testing selected
30 ones of the lines 12-14. The program includes instructions for one or more methods of controlling single-ended measurements on the lines 12-14. The program also includes instructions for methods of analyzing the measurements to

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qualify or disqualify the lines 12-14 for data
transmissions. Both types of method are described below.

       The line testing qualifies or disqualifies the
individual lines 12-14 being tested. To qualify, the
5   computer 30 must predict that the line 12-14, under test,
will support data transmissions without remedial measures.
To disqualify, the computer 30 must predict that the line
12-14, under test, will not support data transmissions
without remedial measures. The computer 30 may perform
10   tests before or after the line 12-14, under test, is in
service for data transmissions.

       Tests to qualify or disqualify a line 12-14 for data
transmission involve several steps. For each step, the
computer 30 signals the switch 15 to disconnect the
15   particular line 12-14, selected for testing, from the line
card (not shown) and reroute the line to the test access 29.
When the switch 15 reroutes the line, the computer 30
signals the measurement unit 27 to perform preselected
single-ended measurements on the selected line 12-14. The
20   measurement unit 27 performs the measurements and returns
results to the computer 30. After receiving the results of
the measurements, the computer 30 signals the switch 15 to
reroute the selected line 12-14 to the line card. Then, the
switch 15 transfers connections for the selected line 12-14
25   to the line card enabling the associated customer unit 16-18
to again communicate with the rest of the network 8.

       FIG. 3 is a flow chart illustrating a method 50 for
determining the suitability of a selected one of the
customer lines 12-14 for a preselected data transmission
30   service. By way of example, the line 12 of FIG. 1 is
selected, but any of the lines 12-14 can be evaluated by the
method 50. Each step of the method 50 includes one or more
single-ended measurements on the selected line 12 and an

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analysis of the measurements by the computer 30 as has been
already described. In addition, the steps of the method 50
fall into two stages.

In the first stage, the computer 30 tests for
5   traditional line faults by performing independent electrical
measurements on the tip and ring wires T, R of the selected
line 12. First, the computer 30 performs such measurements
to determine whether the selected line 12 has any metallic
faults (step 52). Metallic faults include shorts to ground,
10   to a voltage source, or between the paired wires T, R,
and/or capacitive imbalances between the paired wires T, R
of the selected line 12. Second, the computer 30 performs
such measurements to determine whether the selected line 12
has any speed inhibiting faults (step 54). Speed inhibiting
15   faults include resistive imbalances between the paired wires
T, R of the selected line 12, and split pair or load
inductances. Speed inhibiting faults also include bridged
taps that reflect signals resonantly, e.g., the spurious tap
55 shown in FIG. 2, and elevated line-noise levels.

20   The threshold values of single-ended measurements,
which indicate the above-described faults, generally depend
on the type of data transmissions. Methods for performing
and analyzing such single-ended measurements are known in
the art. For example, U.S Application No. 60/106,845
25   ('845), filed November 3, 1998, by Roger Faulkner et al, and
U.S. Patents 5,699,402 ('402) and 4,113,998 ('998) describe
such methods and apparatus. The '845 application and '402
and '998 patents are incorporated by reference, in their
entirety, in the present application. The '402 application
30   and the '402 and '998 patents also describe apparatus 53, of
the measurement unit 27 used for the single-ended
measurements to detect the faults.

If the computer 30 to finds either a metallic or a
speed-inhibiting fault, the computer 30 disqualifies the
selected line 12 for data transmissions (block 56). If the
computer 30 finds no such faults, the computer 30 determines
5   whether the selected line 12 attenuates signals of a
selected frequency by more than a threshold value for the
preselected data transmission service (step 58). In the
absence of faults, the signal attenuation at high
frequencies is the primary measure for determining a line's
10   ability to transmit data.

FIG. 4 shows portions of the measurement unit 27 for
measuring the impedances subsequently used to determine the
attenuation of the selected customer line 12. The
measurement unit 27 includes an AC signal generator 36,
15   which provides an AC driving voltage and current for
measuring the impedances. During the measurements, the AC
signal generator 36 drives two input terminals 40, 41 in a
common mode configuration. The input terminals 40, 41
electrically connect internally at a point 43 to produce the
20   common mode configuration. The terminals 40, 41 also
couple, via the line 28, to the test access 29 of the switch
15. The measurement unit 27 also has a voltmeter 38 to
measure the driving voltage with respect to ground, and an
ammeter 40 to measure the driving current in the common mode
25   configuration.

The test access 29 has internal connections 44,
which electrically couple the tip and ring wires T, R of the
line 12 under test to the terminal 40 and the terminal 41,
respectively. Thus, the tip and ring wires T, R are
30   electrically connected together, at the switch end, so that
the signal generator 36 drives these wires T, R in common
mode configuration during impedance measurements. Driving
the wires T, R in common mode makes electrical measurements

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insensitive to termination characteristics of the customer
unit 16.

Both the preselected threshold value for the signal
attenuation and the preselected frequency depend on the type
5   of data transmission. For ISDN data transmissions, the
preselected threshold is about 45 deci-Bells (dB) at 100
KHz. For ASDL data transmissions, the preselected threshold
is about 40 dB at 300 KHz depending on deployed terminal
equipment.

10   If the signal attenuation at the preselected
frequency is above threshold, the computer 30 disqualifies
the selected line 12 for the corresponding type of data
transmissions (block 56). If the signal attenuation is
below threshold at the preselected frequency, the computer
15   30 qualifies the line 12 for the corresponding type of data
transmissions (block 60) providing no faults were found at
either step 52 or step 54.

FIG. 5 illustrates one method 70 of determining
whether the signal attenuation for the selected line 12 is
20   above the threshold in step 58 of FIG. 4. First, the
measurement unit 27 performs single-ended common-mode
measurements of the capacitance C and the impedance Z of the
selected line 12 as described with relation to FIG. 3 (step
72). The measurements of C and Z are typically low
25   frequency measurements, i.e., between about 300 Hz to 4 KHz,
because the standard test access 29 of the switch 15 does
not necessarily support high frequency measurements. If the
test access 29 supports higher frequency measurements, such
frequencies can be used to set a better resolution on the
30   high frequency attenuation of the selected line 12.

The measurement unit 27 measures the capacitance C
and then uses the value of C to determine the frequency for
measuring the impedance Z. The capacitance C is a lumped

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value between the common mode tip and ring wires T, R and
ground. The measurement unit 27 determines C at a low
frequency, e.g., 80 Hertz (Hz). If the measured value of C
is less than 400 nano-Farads (nF), the AC signal generator
5   27 drives the tip and ring wires T, R in common-mode at
about 2.5 KHz to measure the impedance Z. If the value of C
is greater than 400 nF, the AC signal generator 27 drives
the tip and ring wires T, R, in common-mode, at a higher
frequency between about 3 and 20 KHz, e.g., 3.0 KHz, to
10   measure the impedance Z. The computer 30 uses the relation
Z =V/I, where the voltage V is measured by the voltmeter 38
and the current I is measured by the ammeter 40, to find Z.
       Next, the computer 30 determines the signal
attenuation A(f) at high frequencies characteristic of data
15   transmissions using the low frequency measurements of C and
Z (step 74). The high frequencies are more than ten times
the frequencies used for measuring Z and C. The value of
"A(f)" at higher frequency "f" is known from an empirical
formula (1) given by:
20              $A(f) = K[Z^2 + (2\pi fC)^{-2}]^{-1/2}.$ (1)
The value of K = 5,000 dB-ohms provides good predictions of
the attenuation A(f), in dB, for C and Z (in ohms) measured
at low frequencies as described above. For this value of K,
the frequency f, at which the attenuation is to be
25   determined, should be between about 40 KHz and 300 KHz.
       Next, the computer 30 determines whether the high
frequency attenuation A(f) is above the preselected
threshold for the selected type of data transmissions (step
76). If the attenuation A(f) is above the threshold, the
30   computer 30 disqualifies the selected line 12. If the
attenuation is below threshold, the computer 30 qualifies
the selected line for the selected data transmissions.

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FIG. 6 shows a table 80 comparing values of the signal attenuation A, in dB, at high frequencies, found using the method 70, to reference values, found by an independent method, i.e., simulators. Column 3 of table 80

5   shows the values of A(f) predicted from low frequency measurements of C and Z and the formula (1). Column 4 of table 80 shows the values of A(f) obtained from simulators of customer lines, i.e., the reference values. The values of attenuation A(f) of FIG. 6 are given in dB's at a

10   frequency "f" of about 100 K Hz.

The values of the high frequency attenuation A(f) of the table 80 correspond to a variety of one and two segment structures for the selected customer line 12. Columns 1 and 2 list segment lengths and gauges, i.e., diameters in

15   millimeters, for the copper tip and ring wires T, R of the selected line 12. For each one and two segment structure shown, the predicted and reference attenuations differ by less than about 2 dB. Generally, formula (1) gives values of the high frequency attenuation A, which differ by less

20   than about 3 dB for various segment mixtures if the wire gauges are between about .4 mm and .7 mm and total line lengths are less than about 6.5 km.

FIG. 7 is a flow chart illustrating a method 90 of marketing preselected data transmission services for the

25   customer lines 12-14 of FIG. 1. First, a TELCO performs common-mode single-ended electrical measurements on the selected group of lines 12-14 as described in relation to FIG. 3 and step 70 of FIG. 5 (step 92). Next, the TELCO determines which of the lines 12-14 qualify for the

30   preselected data service from the measurements (step 94). This determination includes performing the steps 74 and 72 of the method 70 of FIG. 5 and may include the steps 52 and 54 of the method 50 of FIG. 4. The determination includes

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sorting the lines based on their final distribution points
and qualification status for the preselected data
transmission service. Next, the TELCO offers the
preselected data transmission service to the portion of the

5   customers to which the lines 12-14 qualified in step 94 are
available, i.e., customers at final distribution points with
qualified lines (step 96). The TELCO connects a portion of
the qualified lines 12-14 to the customers who subsequently
request the offered data services (step 98). The TELCO also

10   bills usage for a portion of the lines 12-14 at prices that
depend on whether the lines 12-14 qualify or disqualify for
the data transmission services (step 100).

         To provide the requested data services at step 98,
the TELCO may swap customer lines to the same final

15   distribution point. The swapping reassigns a qualified line
to a customer requesting data service if the customer's own
line is disqualified. The swap reassigns the customer's
original disqualified line to another customer, who is at
the same final distribution point and not demanding data

20   service. The disqualified line can still provide voice
services to the other customer. Thus, swapping can increase
a TELCO's revenue by making more lines available for more
expensive data services.

         A TELCO can also use swapping in response to a

25   request by the customer for data services. In response to
such a request, the TELCO determines whether the customer's
own line qualifies for the requested service by the above-
described methods. If the line qualifies, the TELCO
provides the customer data services over his own line. If

30   the line disqualifies for the requested service, the TELCO
performs additional qualification tests on other lines to
the same final distribution point, which are not presently
used for data transmission services. If one of those lines

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qualifies for the requested data service, the TELCO swaps
the customer's line with the qualified line. Then, the
qualified line provides data services to the customer
requesting such services and the unqualified line provides
5 normal voice service to the other customer.

Other embodiments are within the scope of the
following claims.

What is claimed is:

1.   A method of assessing the suitability of
customer telephone lines for data transmission, comprising:
        selecting a telephone line having tip and ring wires
via a test access of a switching station;
5   electrically connecting the tip and ring wires
together adjacent one end of the selected line to form a
common mode configuration;
        performing single-ended electrical measurements by
driving the wires in the common mode configuration with
10. respect to ground; and
        determining an electrical property of the wires from
the single ended measurements.

        2.   The method of claim 1, wherein the determining
comprises finding an impedance (Z) of the wires in the
15   common mode configuration.

        3.   The method of claim 2, wherein the performing
comprises driving the wires at low frequencies and the act
of the determining finds a property at a high frequency, the
high frequency being at least ten times the highest one of
20   the low frequencies.

        4.   The method of claim 2, wherein the determining
comprises calculating an attenuation from the impedance.

        5.   The method of claim 4, wherein the measuring
comprises finding a capacitance (C) for the tip and ring
25   wires in the common mode configuration.

        6.   The method of claim 5, wherein the calculating
uses a formula to obtain the attenuation (A(f)), the formula

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being A(f) = K[Z² + (2πfC)⁻²]⁻¹/², the f being the
frequency, and the K being a number.

7.   The method of claim 2, further comprising:
      determining whether the selected line has a line
5 fault; and
      disqualifying the line in response to finding the
line fault.

8.   The method of claim 2, wherein the fault is a
speed inhibiting fault.

10   9.   The method of claim 8, wherein the speed
inhibiting fault includes one of a resistance imbalance, a
bridged tap, a load coil, and a noise level above a
preselected threshold.

10.   The method of claim 8, wherein the line fault
15 includes a metallic fault.

11.   The method of claim 10, wherein the metallic
fault includes one of a capacitance imbalance, a short to
ground, a short to a voltage source, and an intermediate
short between the tip and ring wires.

20   12.   The method of claim 10, further comprising:
      determining whether the selected line has a speed
inhibiting fault; and
      disqualifying the line in response to finding the
speed inhibiting fault.

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13.   The method of claim 8, wherein the act of
determining an electrical property includes calculating an
attenuation for the line using the electrical measurements.

14.   A system for determining signal attenuations of
5   customer telephone lines, each line having tip and ring
wires, comprising:
      a measurement unit having first and second input
terminals to couple to a test access of a telephony switch,
the measurement unit capable of driving the input terminals
10   in a common mode configuration to perform single-ended
impedance measurements on the tip and ring wires of the
customer lines.

15.   The system of claim 14, wherein the measurement
unit further comprises:
15   a voltmeter coupled to measure a voltage driving
said input terminals in the common mode configuration; and
          an ammeter coupled to measure a current going to
said input terminals in the common mode configuration.

16.   The system of claim 15, wherein the measurement
20   unit further comprises:
      a signal generator connected to the first and second
terminals to drive said terminals in the common mode
configuration.

17.   The system of claim 15, wherein the measurement
25   unit further comprises apparatus to perform single-ended
measurements to detect one of metallic faults and speed
inhibiting faults on the customer lines.

18.   The system of claim 14, further comprising:

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a processor coupled to the measurement unit and
capable of coupling to the switch, the processor having a
data storage medium encoding a program of instructions for a
method, the method comprising:

5   ordering the measurement unit to perform the single-
ended measurements; and

analyzing results of the ordered measurements to
determine a signal attenuation of the one of the customer
lines.

10   19. The system of claim 18, wherein the method
further comprises:

determining whether the one of the lines is
qualified to transmit data from the signal attenuation.

20. The system of claim 18, wherein the signal
15 attenuation corresponds to a frequency at least ten times
frequencies at which the measurement unit is capable of
driving the one of the lines through the test access.

21. The system of claim 18, wherein the method
further comprises:
20   ordering the switch to transfer connections for the
one of the lines from the network to the test access prior
to the act of ordering the measurement unit.

22. The system of claim 14, further comprising:
the switch having the test access, the switch being
25 a central office switch.

23. The system of claim 17, wherein the test access
is adapted to transmit electrical signals having voice-range
frequencies.

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24. A program storage device encoding an executable
program of instructions for a method of determining the
signal attenuation of customer telephone lines connected to
a central switch, the method comprising:

5   ordering the switch to transfer connections for one
of the lines from the network to a test access of the
switch;

        ordering a measurement unit to perform single-ended
impedance measurements on tip and ring wires of one of the
10 lines by driving the tip and ring wires in a common mode
configuration using the test access; and

        analyzing results of the ordered measurements to
determine a signal attenuation of the one of the customer
lines.

15   25. The device of claim 24, wherein the method
further comprises:

        determining whether the one of the lines is
qualified to transmit data from the signal attenuation.

        26. The device of claim 24, wherein the signal
20 attenuation corresponds to a frequency (f) at least ten
times signal frequencies of the single-ended measurements.

        27. The device of claim 26, wherein the act of
analyzing comprises:

        calculating the attenuation (A) based on a formula,
25 the formula being $A(f) = K[\ Z^2 + (2\pi fC)^{-2}\ ]^{-1/2}$, and

        wherein Z and C are the respective impedance and
capacitance of the line in the common mode configuration.

        28. The device of claim 24, the method further
comprising:

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determining whether the selected line has a line
fault; and
disqualifying the line in response to determining
that the line has a fault.

5   29. A method of marketing customer telephone lines
for a selected data transmission service, each line having
associated tip and ring wires, comprising:
automatically performing single-ended electrical
measurements on a selected plurality of customer telephone
10   lines while the associated tip and ring wires are connected
together in a common mode configuration;
determining which of the customer lines qualify for
the selected data service from the measurements;
sorting the lines based on final distribution points
15   and qualification for the data service; and
offering the selected data service to a portion of
the customers in response to said portion having qualified
lines available.

30. The method of claim 29, further comprising:
20   billing customers for usage of the lines at rates
depending on whether the lines qualified for the selected
data transmission service.

31. The method of claim 29, wherein the act of
determining includes finding a signal attenuation of the
25   lines and qualifying lines having signal attenuations below
a preselected threshold.

32. The method of claim 31, further comprising:
monitoring a second portion of the customer lines
after being placed in service by

repeatedly performing one-ended common-modes
electrical measurements on the second portion; and
    determining which of the lines of the second portion
are qualified for the selected data transmission service
5 from the repeated measurements.

    33. The method of claim 29, further comprising:
    providing the data transmission service for a second
portion of the lines qualified for the selected data
transmission service in response to receiving requests from
10 the associated customers for the service.

    34. A method of marketing data transmission
services to customers over telephone lines having associated
tip and ring wires, comprising:
    performing single-ended electrical tests on a
15 plurality of telephone lines connected to a final
distribution near where a customer is located, the tests
driving tip and ring wires of the lines under test in a
common mode configuration;
    determining whether the tested lines qualify for a
20 selected data service; and
    offering the data service to the customer over one
of the tested lines in response to the one of the tested
lines being qualified.

    35. The method of claim 34, further comprising:
25 swapping the one of the tested lines with a line
originally used by the customer in response to the line
originally used by the customer being disqualified for the
data service.

36. The method of claim 35, wherein the act of
determining includes finding a signal attenuation of the
tested lines and qualifying the tested lines having signal
attenuations below a preselected threshold.

5   37. The method of claim 34, wherein the act of
performing tests is responsive to receiving a request from
the customer for the selected data service.

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Fig.1.

Fig.2.

Fig.3.

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Fig.4.

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70

72

Perform single-ended measurements of
Z and C at low frequencies of twisted
wire pair

No

74

Determine high frequency attenuation
From   A= $\dfrac{5000}{(Z^2 +(2\pi fC)^{-2})^{1/2}}$ dB

76

Is
high frequency
attenuation above
the threshold
?

Yes

56 — Disqualify

No

60 — Qualify
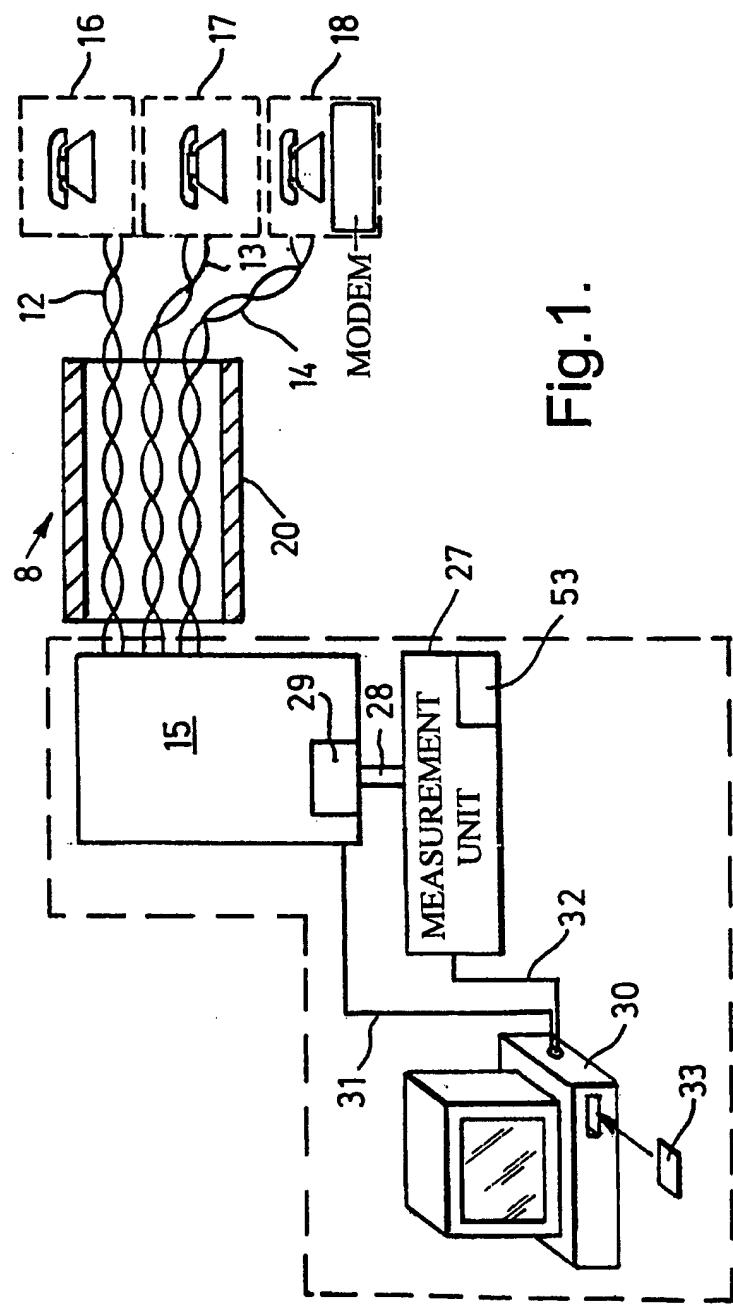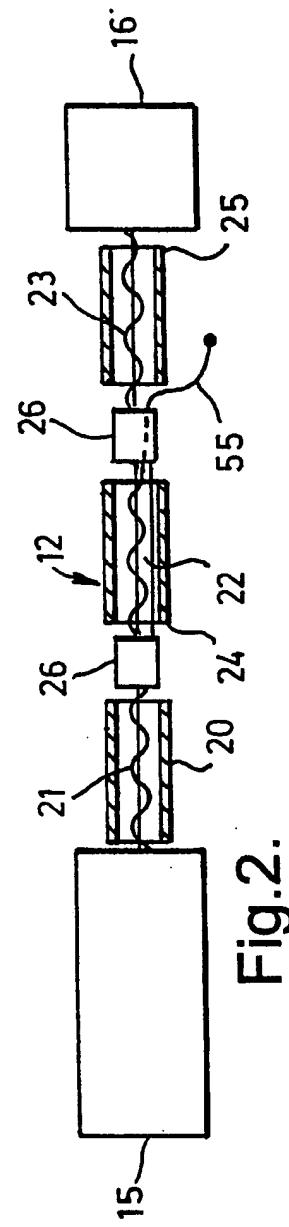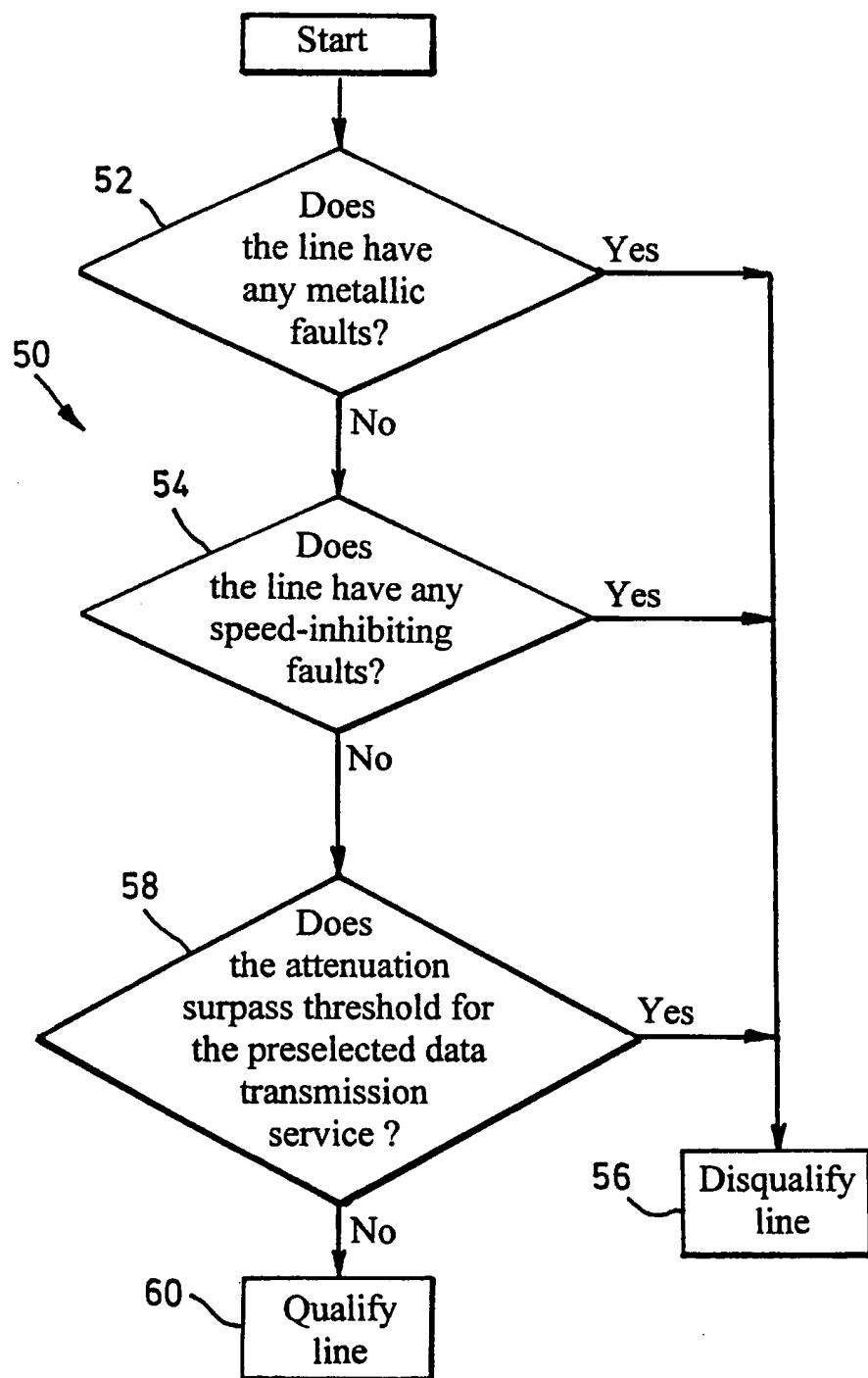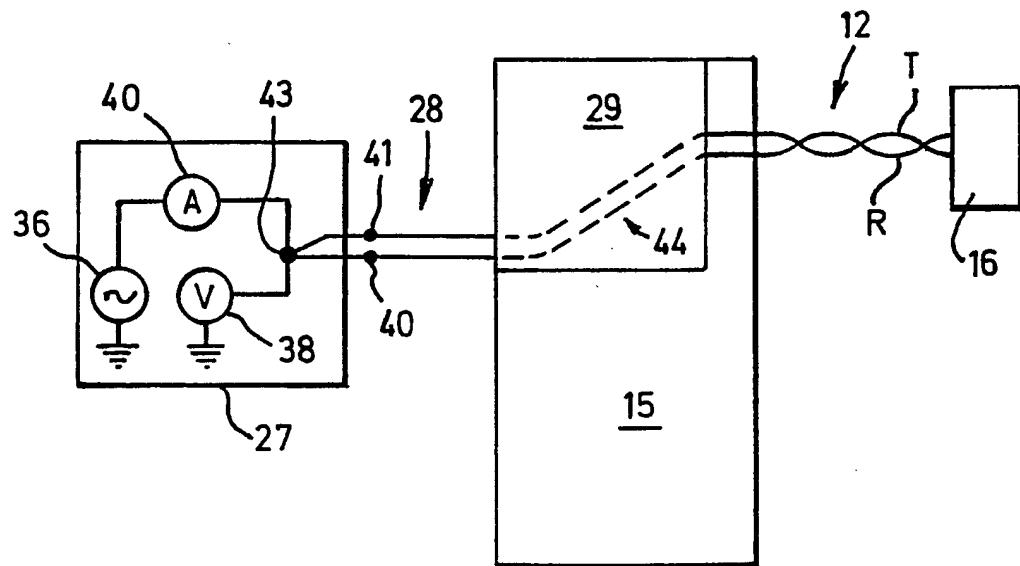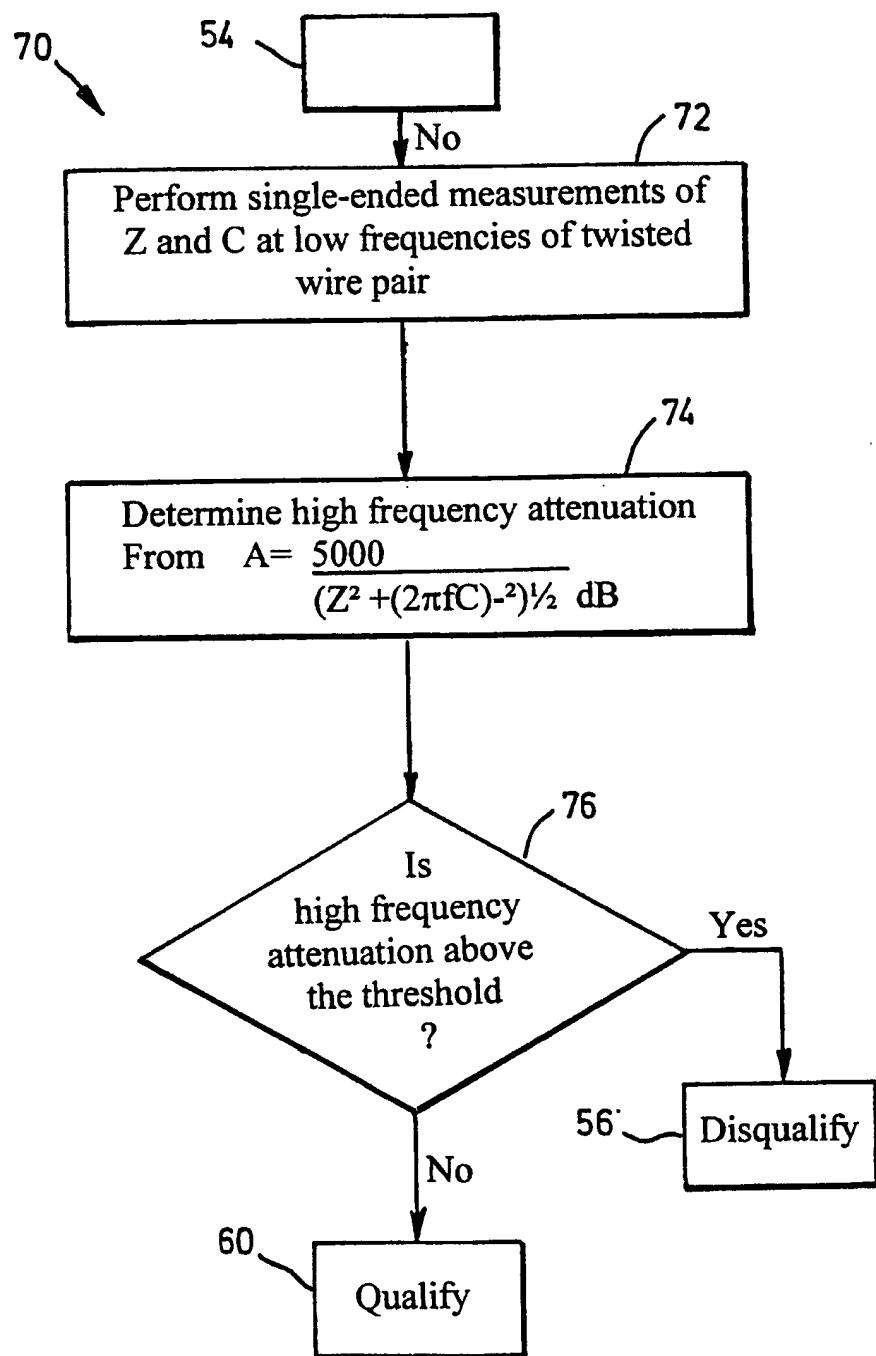
Fig.5.

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Segment 1	Segment 2	Measure +formula	Reference values
2km .6Cu		12 .39dB	12 .4dB
2km .6Cu	2km .6Cu	24 .17dB	12 .8dB
2km .6Cu	2km .5Cu	25 .59dB	27 .4dB
2km .5Cu		14 .26dB	15dB
2km .5Cu	2km .5Cu	29 .13dB	30dB
2km .6Cu	500m .5Cu	16 .74dB	15 .65dB
500m .5Cu	2km .6Cu	15 .92dB	15 .65dB
500m .5Cu	4km .6Cu	27 .04dB	28 .05dB
500m .5Cu	6km .6Cu	40 .30dB	40 .45dB

    1   2   3   4

Fig.6.

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90

Perform single-ended electrical measurements
on selected customer lines by driving the
wires of the line in common mode

92

Determine which of the lines qualify for
selected data service from the measurements

94

Offer the data service to the customers
having the qualified lines available

96

Connect a portion of the qualified lines
for data service in response to requests for
the service from the associated customers

98

Bill customers for line usage at rates
dependent on whether line has been qualified

100

Fig.7.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	BACKER, TODD; PUCKETT, RICK: "Telephone Access Network Measurements" 1998 , TEKTRONIX XP002148949 paragraph '0017!	1,14,24
A	"IEEE Std 743-1995 IEEE Standard Equipment Requirements and Measurement Techniques for Analog Transmission Parameters for Telecommunications" 1996 , IEEE , US XP002148950 paragraph '10.6!	1,14,24
A	US 5 699 402 A (BAUER FRANK R ET AL) 16 December 1997 (1997-12-16) cited in the application column 25, line 20 -column 29, line 53	1,14,24
X	HEDLUND, ERIC; CULLINAN, TOM: "DSL Loop Test" TELEPHONY, vol. 235, no. 8, 24 August 1998 (1998-08-24), pages 48-52, XP002147002 USA the whole document	29,34

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